Expert System Software Assistant for Payload Operations Control Team

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The Payload Operations Control Center (POCC) at MSFC has been the leader in innovative approaches to payload operations since 1987. Beginning with the flight of the Astro–1 Spacelab mission, POCC operations personnel in the Mission Operations Laboratory at MSFC have been concerned with operational efficiency and reducing the cost of Spacelab payload operations, while maintaining a high level of responsiveness to the science user's requirements and mission needs. A labor intensive area for flight preparation has been the development of special software and ground displays to monitor critical telemetry of payloads and Spacelab payload support systems. Additionally, the real-time mission support task of monitoring this data during flight has often required two payload system engineers (PSE) to provide timely and adequate response to anomalies and to assess potential problems identified in telemetry before they develop into major concerns. In an effort to find better and more cost effective ways of addressing these payload operations needs, the Office for Life and Microgravity Sciences and Applications at NASA Headquarters provided funding for an integrated team of McDonnell Douglas carrier subsystem experts, Teledyne Brown payload experts, and NASA MSFC operations control experts to develop and deploy a mission software knowledge base using the McDonnell Douglas Optimized Advanced System Integration and Simulation tool developed in the G2 expert system environment. G2 is a commercially available product developed by the Gensym Corporation. The broad objective of this G2-based application was to demonstrate the enhancements and cost savings that can be achieved through expert system software utilization payload operations in a ground control center. Spacelab provided a valuable proving ground for this advanced software technology—a technology that will be exploited and expanded for future *International Space Station* operations.

So, when the STS–75 mission launched on February 22, 1996, the operations personnel in the POCC welcomed a new member to their team. This new member was not a trained engineer, but rather a trained computer. The Operations Execution Assistant (OEA) expert system accurately and tirelessly watched both United States Microgravity Payload–3 and Tethered Satellite System–1R (USMP–3/TSS–1R) flight telemetry during the entire mission. Users were provided data via graphic interfaces on any off-nominal conditions that occurred on orbit. The focus of the tool was to demonstrate payload command and control efficiency improvements through the use of "smart" software which monitors flight telemetry, provides enhanced schematic-based data visualization, and performs advanced engineering data analysis. Features for the STS–75 mission included schematic-based monitoring of 512 telemetry readings using an intuitive object-based graphical user interface, exception limit monitoring, a messaging system, advanced diagnostics, real-time plots, trend analysis, automated malfunction procedure execution, crew message downlink, data logging, and quick recall of stored telemetry through a near real-time plot utility. The OEA knowledge base was hosted on a SunSparc20 workstation which received the real-time telemetry via an

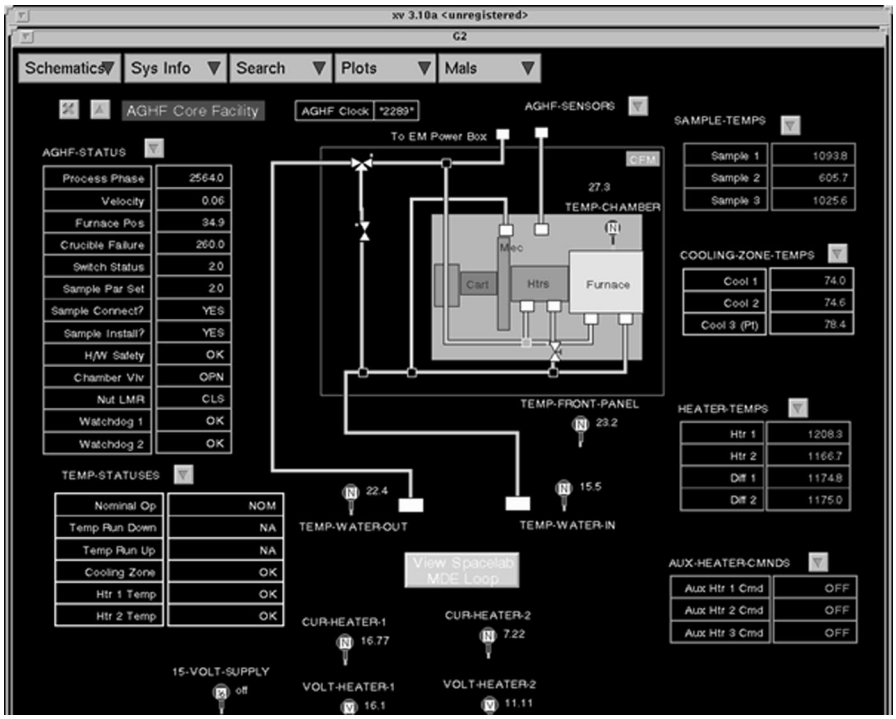

FIGURE 118.—Various workspaces provided by the Operations Execution Assistant (OEA) show the schematic-based data visualization which includes animation, the real-time data plotting, and the expert system messaging panel.

asynchronous data subset that was fed to the system once per second through a custom G2 Standard Interface bridge. The bridge C code decoded the raw data block, performed engineering units conversion, and passed changed data into the OEA system. Figure 118 shows a typical OEA tool display. The OEA expert system tool was labeled as "invaluable" and "indispensable" by the POCC operations personnel who used it. In the software debrief held after the USMP–3/TSS–1R mission, Richard Weaver, one of the Payload Systems Engineers from Teledyne Brown Engineering, stated, "It would not have been possible for one position (one person) to effectively monitor all the subsystems for this complex mission had it not been for the OEA tool." The OEA was also used successfully on the Life and Microgravity Science (LMS) mission in June 1996 and is being prepared for the Microgravity Science Laboratory mission planned for March 1997.

In conclusion, expert system technology has great potential for effective use in the payload mission operations environment. The environment nature of commercial tools like G2 greatly reduces the manpower necessary to develop and deploy payload operations support systems like OEA and simultaneously multiplies a single operator's ability to monitor telemetry and respond in a timely manner. These kinds of systems will become increasingly important to NASA during the Space Station era as the need for reduced operations cost increases.

Sponsor: Office of Life and Microgravity Sciences; Spacelab Payload Projects Office

Industry Involvement: McDonnell Douglas Aerospace

Biographical Sketch: Mark N. Rogers has been with Marshall since 1991. Completing his bachelor of science in electrical engineering at the University of Alabama, he began his career developing payload operations concepts for the Space Station. Rogers has served as experiment computer operator for the ATLAS–3 mission and as operations controller for the LMS mission. In 1996, Rogers received the NASA Special Service Award for innovation in the application of expert systems to payload flight operations. Currently, Rogers is a team member in the Flight Control Branch and is responsible for the development of operations concepts for future NASA payload projects.

Richard Mark McElyea has been with Marshall since 1981. Completing his bachelor of science in industrial and systems engineering at the University of Alabama in Huntsville, he began his career developing simulation hardware and software to support payload flight crew training. In 1983, McElyea moved from crew training to payload operations control where he served as operations controller for the Astro–2 mission. Currently, McElyea is a team lead in the Flight Control Branch and is responsible for the development of operations concepts for future NASA payload projects. He was awarded the NASA Exceptional Service Medal in 1995 for outstanding leadership in the management of continuous improvements in Spacelab operations.